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**LISTS OF SPECIES**

# On Dactylogyridae (Monogenea) of four species of characid fishes from Brazil

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## Abstract
Material collected from the fishes from the dams and fish farms of the *Departamento Nacional de Obras contra as Secas* (DNOCS) and from the tanks of the Itaipu Hydroelectric Station was examined in order to analyze the index and the infestation of Monogenea. Specimens of *tambaqui* (*Colossoma macropomum*), *pacu* (*Piaractus mesopotamicus*), *pirapitinga* (*Piaractus brachypomus*) and the hybrid *tambacu* (*Colossoma macropomum* X *Piaractus mesopotamicus*) were examined and five species of Monogenea were identified including: *Mymarothecium viatorum* Boeger, Piasecki & Sobecka, 2002, *Mymarothecium boegeri* Cohen & Kohn, 2005, *Notozothecium euzeti* Kritsky, Boeger & Jégu, 1996, *Notozothecium januachensis* Belmont-Jegu, Domingues & Martins, 2004 and *Anacanthorus penilabiatus* Boeger, Husak & Martins, 1995. Infection prevalence and intensity of infection and new data concerning Monogenea are presented. Key words: Monogenea, Parasites, Brazil, freshwater fishes.

## Introduction
Brazil is internationally recognized as one of the main countries with a great pisciculture, with vast areas and a climate favorable for the development and implementation of freshwater fish cultivation. *Colossoma macropomum* and *Piaractus mesopotamicus* are among most commonly cultivated fish species in Brazil (Martins et al. 2002).

Parasites could cause on losses in piscicultural facilities, especially in the Neotropical region due to ecological characteristics that facilitate the rapid and constant spread of various parasites (Schalch et al. 2006). Because of these losses to the piscicultural enterprise by parasites it is obvious that further and more detailed studies of these pathogenic agents are necessary, including morphological characterization, understanding the relationships between parasites and hosts, and the influence of the parasitism on host health.

Research into monogenean parasites of fishes belonging to Characidae has been conducted in several countries: Eiras et al. (1995), Martins and Romero (1996), Tavares-Dias et al. (2001); Martins et al. (2000; 2002); Fischer et al. (2003); Schalch and Moraes (2005) and Schalch et al. (2006) from Brazil, Aragot and Moreno (1997), Aragot et al. (2002) and Centeno et al. (2004) from Venezuela and Prieto (1989) in Cuba.

Studies regarding parasitism of fishes by the different groups of helminths in the pisciculture stations of the "*Departamento Nacional de Obras Contra as Secas*, DNOCS" in the localities of Pentecoste, Amanari, Sobral and Icó, in the state of Ceará, Brazil, demonstrated that high infection indices were shown by the Monogenea, mostly species of the family Dactylogyridae (Kohn et al. 2004)

Continuing these studies, four Characidae species were examined to study Monogenea: *Colossoma macropomum* (Cuvier, 1916), "*tambaqui*", *Piaractus brachypomus* (Cuvier, 1918), "*pirapitinga*", *Piaractus mesopotamicus* (Holmber, 1887), "*pacu*" and the hybrid *C. macropomum* x *P. brachypomum* from DNOCS dams and fish farms and *P. mesopotamicus* from the Itaipu Hydroelectric Power Station reservoir, located at Foz do Iguaçu.

## Material and Methods
Fishes examined were obtained from the following DNOCS Pisciculture farms: the Rodolfo von Ihering Research Center, located in Pentecoste, supplied by the Pereira de Miranda dam; the Valdemar C. de França Pisciculture Unit, located in Amanari, Maranguape, supplied by the Amanari dam, Osmar Fontele Pisciculture Unit, in Jaibaras; Sobral, supplied by the Ayres de Souza

dam; and the Pedro de Azevedo Station, supplied by the Lima Campos dam, in Icó, all in the State of Ceará; and from the Itaipu Hydroelectric Power Station reservoir located in Foz do Iguaçu, in the state of Paraná, Brazil.

The fishes from the dams were collected using dragnets and fishhooks and those from fish farms were collected using dragnets and fish traps and transported to the station's laboratories, where living specimens were maintained in barrels for subsequent examination.

The Monogena collected were processed according to Boeger and Vianna (2006) and mounted on slides in Hoyer's medium to allow identification of the sclerotized internal structures.

**Results**

Twenty-nine specimens of *Piaractus mesopotamicus* collected at the Itaipu Hydroelectric Power Station reservoir were examined, of which 23 (79,3%) were parasitized by Monogenea. From the DNOCS fish farms, five specimens were also examined, with a 100% of prevalence. Of the total of 28 *Piaractus brachypomus* specimens examined from the DNOCS fish farms, 7 (25%) were parasitized by species of Monogenea.

*Piaractus mesopotamicus* and *P. brachypomus* (Characidae) harbored two species of Dactylogyridae: *Anacanthorus penilabiatus* and *Mymarothecium viatorum*. From 30 *Colossoma macropomum* examined, 18 (60%) were parasitized by three monogenean species: *Mymarothecium boegeri*, *Notozothecium janauachensis* and *Notozothecium euzeti*, for the last species, this is the first record of parasitism in *C. macropomum*.

Two hybrids of *C. macropomum* and *P. brachypomus* examined from the fish farms in the locality of Sobral were parasitized by *M. boegeri*, reported herein as a new host record.

**Discussion**

In the present study, the index of parasitism was analyzed from samples taken from areas with intensive fish culture, where high levels of infestation in the DNOCS fish farms and dams and in the Itaipu Hydroelectric Power Station reservoir were observed, confirmed by the large quantities of Monogenea (prevalence and intensity) collected during host examinations.

In *C. macropomum*, three dactylogyrid species were found: *Notozothecium euzeti, N. januachensis* and *Mymarothecium boegeri*. As shown in Table 1, the number of parasites specimens obtained was very high, principally of *N. januachensis*. The total number of specimens collected was 7342, removed from 18 out of 30 fish examined, of which 5277 (71.7%) were identified as *N. januachensis*.

*Notozothecium euzeti* was described by Kritsky et al. (1996) parasitizing the gills of *Acnodon normani* Gosline, 1951 (Characidae), from the Xingu River in the State of Pará. In the present study, *N. euzeti* was identified in a new host, *Colossoma macropomum* from the DNOCS fish farms in the State of Ceará.

*Notozothecium janauachensis* was described in Brazil by Belmont-Jegú et al. (2004), also removed from the gills of *C. macropomum* collected from Janauacá Lake, state of Amazonas and from the fish farms of "*Centro de Aquicultura da Universidade Estadual Paulista*", Jaboticabal, state of São Paulo.

Prieto (1989) studied the effects of parasitism in *C. macropomum* in Cuba and identified two monogenean species, *Anacanthorus spathulatus*, *Linguadactyloides brinkmanni*, as well providing a description of an undetermined species, with a brief characterization of anchors and bars, suggestive of *N. janauachensis*.

Fischer et al. (2003) studied the parasitic fauna of *C. macropomum* collected from the River Solimões and reported the presence of *A. spathulatus* and *L. brinkamnii*. Besides these species, the authors reported *Notozothecium* sp., though without any measurements or a detailed description of the parasites recovered. Considering that two species of the genus *Notozothecium* were identified in this work, it is impossible to establish which species the authors collected.

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In Venezuela, Aragot and Moreno (1997) and Aragot et al. (2002) studied the epidemiology and pathology of Monogenea from *C. macropomum*, and reported infections by *A. spathulatus* and *L. brinkmanni*. Centeno et al. (2004) examined specimens of *Colossoma macropomum* and the hybrid *C. macropomum* x *P. brachypomus* and identified *A. spathulatus*, as well as several protozoans and myxosporidia.

The identification of different species of *Notozothecium* in Characid fishes widens the previously reported distribution of species of this genus, a fact that could be useful as a phylogenetic tool, further contributing to the elucidation of the evolution of these parasites and their hosts.

*Mymarothecium boegeri* was described by Cohen and Kohn (2005) in *C. macropomum* collected at the fish farms of the DNOCS research stations in the state of Ceará. In the present work, this species was detected in the type host and in the hybrid *C. macropomum* x *P. brachypomum*, which is a new host record for this species.

Comparison of the monogenean fauna identified in *C. macropomum* from several locations showed that different species were obtained in the present study (Table 2). Reports from Venezuela, Cuba and from different Brazilian regions identified two other monogenean species: *Anacanthorus spathulatus* and *Linguadactyloides brinckmanni*, parasitizing the gills of *C. macropomum*. These species were not recovered from fishes collected at the DNOCS research stations, showing a difference in the composition of the parasitic fauna among these locations. *Notozothecium janauachensis* has a wide distribution, reported from the Amazonas, São Paulo and Ceará states, besides the unidentified species reported from Cuba, which could well be this species. Unfortunately, no voucher specimens could be located to confirm the identification.

In the present study, *Piaractus brachypomus* and *P. mesopotamicus* were parasitized by two previously recorded species: *Mymarothecium viatorum* and *Anacanthorus penilabiatus*, the latter one presenting low abundance (Table 2).

*Mymarothecium viatorum* was described by Boeger et al. (2002) parasitizing the gills of *P. brachypomus* in the River Odra, in Poland. Cohen and Kohn (2005) collected specimens of *M. viatorum* from *P. brachypomus* and from *P. mesopotamicus* in Brazil, confirming the occurrence of this species in the type host and in other congeneric species from the Neotropical region.

*Anacanthorus penilabiatus* was originally described by Boeger et al. (1995) parasitizing the gills of cultivated *Piaractus mesopotamicus* in the state of São Paulo and Pamplona-Basilio et al. (2001) identified this parasite parasitizing the gills of *Colossoma macropomum* and *Piaractus brachypomus* in the state of Ceará.

Specimens of *P. mesopotamicus* showed high prevalence, and, as in *P. brachypomus*, *M. viatorum* was more abundant in the two regions studied. Martins et al. (2002) studied the parasitic fauna of *P. mesopotamicus* and reported that *Anacanthorus penilabiatus* presented the highest prevalence. In the same host, Lizama et al. (2007) also reported the higher prevalence of *A. penilabiatus* species upon *A. spathulatus*, *Anacanthorus* sp. and two unidentified species of *Mymarothecium*.

Studies of the helminth fauna in cultivated forms of *C. macropomum* and *P. mesopotamicus* were conducted, to determine levels of parasitism relative to occurrence and seasonality, demonstrating a high prevalence of Monogenea, but no specific identification of the species obtained has been published (Eiras et al. 1995; Martins and Romero, 1996; Martins et al. 2000; 2002; Tavares-Dias et al. 2001; Schalch and Moraes 2005; Schalch et al. 2006).

Two specimens of the hybrid *Colossoma macropomum* x *Piaractus brachypomus* were examined and showed high rates of infestation by a single species, *M. boegeri*. However, further studies should be conducted to confirm the uniqueness of this parasitism, since the two parental species were parasitized by three and two different species, respectively.

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Centeno et al. (2004) compared the parasitic fauna of *C. macropomum* with those of the hybrid *C. macropomum* x *P. brachypomus* from Venezuela and found high prevalence of *Anacanthorus spathulatus* in the two host species. The present study showed that hybrids from the state of Ceará were only parasitized by *M. boegeri*, which is not one of the most prevalent species in *C. macropomum*.

The fish species studied, belonging to the genera *Colossoma* and *Piaractus* (Characidae), are phyllogenetically closer. According to Kritsky et al. (1996), *Mymarothecium* and *Notozothecium* are apparently sister taxa, but patterns of association of species of these genera with their host differ: *Notozothecium* occurs in members of six host genera (*Myleus, Acnodon, Mylesinus, Pristobrycon*, *Pygocentrus* and *Serrasalmus*), whereas *Mymarothecium* is restricted to a single subfamily, parasitizing *Pygocentrus, Pristobrycon* and *Serrasalmus*. Kritsky et al. (1996) suggested that the associations of *Notozothecium* and *Mymarothecium* are relatively old, with the common ancestor of the genera occurring in an early serrasalmid form.

The results of the present study reinforce the argument of Kritsky et al. (1996), considering the finding of two species of *Notozothecium* in *Colossoma macropomum* (one originally described in this host and other reported here for the first time) and one species of *Mymarothecium* described in this host, *M. boegeri*. Additionally, *Mymarothecium viatorum* was reported in *Piaractus brachypomus* and *P. mesopotamicus*, species phylogenetically closer each other and with *Colossoma macropomum*.

**Table 1.** Prevalence (P), Mean intensity (MI), Mean abundance (MA) and Range of intensity (RI) of Monogenea from different host from dams and fish ponds from DNOCS.

***Colossoma macropomum***

| Parasites | P | MI | MA | RI | Total number |
|---|---|---|---|---|---|
| *Notozothecium janauachensis* | 60 % | 292.5 | 175.5 | 8-2299 | 5266 |
| *Mymarothecium boegeri* | 50 % | 108.2 | 54.1 | 3-867 | 1623 |
| *Notozothecium euzeti* | 50 % | 30.2 | 15.1 | 1-185 | 453 |

***Piaractus mesopotamicus***

| Parasites | P | MI | MA | RI | Total number |
|---|---|---|---|---|---|
| *Mymarothecium viatorum* | 100 % | 277 | 277 | 54-854 | 1662 |
| *Anacanthorus penilabiatus* | 50 % | 23.6 | 11.8 | 13-42 | 74 |

***Piaractus brachypomus***

| Parasites | P | MI | MA | RI | Total number |
|---|---|---|---|---|---|
| *Mymarothecium viatorum* | 100 % | 105.7 | 105.7 | 24-318 | 740 |
| *Anacanthorus penilabiatus* | 83.3 % | 17.5 | 15 | 15-32 | 112 |

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**Table 2.** Records of Monogenea parasites of *Colossoma macropomum*. 1. Cuba (Prieto, 1989); 2. Ceará, Brazil (Pamplona–Basilio et al., 2001); 3. Portuguesa, Venezuela (Aragot & Moreno, 1997, Aragot et al. 2002); 4. Amazonas, Brasil (Fischer et al., 2003); 5. Delta Amacuro, Venezuela (Centeno et al., 2004); 6. Amazonas, Brazil (Belmont–Jegu et al., 2004); 7. São Paulo, Brazil (Belmont–Jegu et al., 2004); 8. Ceará, Brazil (present paper)

| Species | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 |
|---|---|---|---|---|---|---|---|---|
| *Anacanthorus spathulatus* | X | | X | X | X | | | |
| *Linguadactyloides brinkmanni* | X | | X | X | | | | |
| *Notozothecium* sp. * | X | | | X | | | | |
| *Notozothecium janauachensis* | | | | | | X | X | X |
| *Anacanthorus penilabiatus* | | X | | | | | | |
| *Mymarothecium boegeri* | | | | | | | | X |
| *Notozothecium euzeti* | | | | | | | | X |

* probably *Notozothecium janauachensis*

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